Allyn Vine

A Report for
the Secretary of Commerce

Engineering IN THE Ocean

by the
National Advisory Committee on Oceans and Atmosphere

November 15, 1974

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National
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Committee on
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November 15, 1974
Washington, D.C.

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NATIONAL ADVISORY COMMITTEE
ON
OCEANS AND ATMOSPHERE
Washington, D.C. 20230

15 November 1974

Honorable Frederick B. Dent
Secretary of Commerce
Washington, D.C. 20230

Dear Mr. Secretary:

In your letter of August 21, 1973, you asked NACOA to define the national need in civilian ocean engineering, and to discuss who ought to be responsible, as between the private sector and the government, for meeting particular portions of it.

Our reply has been longer in coming than we had intended. There turned out to be no obvious consensus in the answers to the questions you have asked. Reasonable suggestions for improving the national effort have been made by many—in studies over the last decade and in the interviews staff conducted during the last year. There were persuasive arguments for developing various aspects of engineering in the oceans. But no specific applications of ocean engineering to civilian needs swept the field as critical, urgent, national in scope, yet neglected.

The panel we appointed to look into this matter consisted of Dr. Donald B. Rice, Chairman, Mr. Charles F. Baird, Dr. Dayton H. Clewell, and Mr. Elmer P. Wheaton. It reports that it found itself in a position of concluding that the paramount national civilian ocean engineering need is not a specific number of projects in ocean engineering, but rather a modest organization whose function it would be to:

a) work on and develop standards which presently, in ocean engineering, lag other engineering;

b) fund good ideas in meeting basic engineering needs to the point where they could generate support on their merit or fade away on their lack of it; and

c) animate technical transfer and professional communications.

The basic needs would be concerned not so much with systems as with special materials, techniques, and engineering characteristics required for many different kinds of marine operation.

make the ocean a place we felt

In view of our present
[illegible] !!!

The panel came to the conclusion somewhat unwillingly that an organization rather than a specific program was needed. Its expectation had been that at least several agreed-upon ocean engineering tasks would emerge as outstanding and essential to the civilian sector. It was aware of extensive Navy work in many of the areas of interest. The panel was prepared to find that if no agreement on particular civilian applications emerged as especially significant there was no real need, national in scope, for a civilian ocean engineering program.

But that did not settle the matter. Despite the fact that no "winners" emerged, the panel also became convinced that we would all be the losers if things were allowed to drift in ocean engineering as they have over the last decade. There is need for technical alternatives to be on hand when decisions are made so as not to be trapped into expedient, possibly environmentally detrimental, actions. There are simply too many things that should be done to avoid being caught by surprise in our expanding and conflicting uses of the oceans offshore, in the coastal zone, in the depth and the breadth of the sea.

None of the needs developing from this increased activity, by themselves, make for a national program. But together they seem to require a stimulus to progress because they fall into the gap which lies between short- and long-term programs and between the responsibilities of the private and governmental sectors. The gap lies between the immediately-targeted projects of the private sector in getting on with its operations (during which engineering problems are solved as part of the project) and the lower-keyed longer-range targeting of the government sector in laying in a broad fund of knowledge upon which we can all draw as time goes on. The former is quite specific, the latter quite general. The question of the relative roles of government and of industry is involved because each, to some extent, looks to the other to cover the inbetween area. The panel speaks of this grey area in more detail in its memorandum report which I forward with this letter.

Ocean engineering is more expensive than engineering on land, the panel noted, and the benefits are often harder to assess than the costs. This open-ended uncertainty is one reason recommendations in the past to start broad programs in ocean engineering have been unpersuasive. But the panel felt it a mistake to take an all-or-nothing attitude about supporting and funding this work, especially since one reason ocean engineering is expensive is that its development is so uncoordinated.

While there are a number of ways in which this situation could be ameliorated, and it is disappointing that it has not proved practical to take full advantage for civilian purposes of the Navy's work in ocean engineering, NACOA proposes that an Institute for Engineering Research in the Oceans, with a strength of about 150 professionals,

be established as the effective way of organizing ocean engineering development without incurring large down-stream costs. To encourage the formation of a focus for marine affairs in NOAA, we believe this Institute should report to the Administrator of NOAA, who would maintain it as a distinct entity with appropriate bonds to other government agencies who have engineering tasks to perform in the oceans such as the Department of Interior, the Navy, the Coast Guard, etc. The Institute should be authorized startup funding of $5, $15, and $25 million for three successive years with a mandatory reexamination and re-evaluation of the effort starting two years after day one and a major reassessment five years later. The task of this Institute would be to stimulate and support engineering research (advanced development) in the oceans to meet civilian needs by using seed money to get good work started but not supported indefinitely. *The essential task of the Institute would be to range the field rather than get bogged down in expensive demonstration programs.* It would be to support work and act as a catalyst in new areas of special materials and techniques which would serve a multiplicity of marine activities. It would have a central responsibility for improving professional communications and encouraging the development of standards.

To do this job the Institute would have to have the in-house technical capacity to be stimulated by technical problems, to help prevent falling behind in ocean technology, and to monitor the technical quality of contracts. It would need a Board of Governors representative of industry, the universities, and government to exert the pressure to keep the Institute technically competitive. It would be desirable to have a mix in funding with a major portion of the disbursed funds being used for direct out-of-house support and for fund-matching with outside sources as an earnest of effort and as a check on judgement. Thirty to forty percent should be reserved for in-house efforts or centralized facilities.

Det Norske Veritas, the highly regarded technical research and standards-setting agency in Norway which uses a mix of government, private, academic, and professional expertise on marine and offshore problems is an example of the organizational status we have in mind.

One of the National Institutes of Health with a touch of the National Bureau of Standards would be a closer analogy amongst U.S. institutions in organizational structure—more so, for example, than the Office of Naval Research or the Institutes which grew up around the Department of Defense in the fifties and sixties. The reason is that the mission of the Institute for Engineering Research in the Oceans would be to catalyze activity for many users who are dispersed throughout the nation rather than to stimulate technical activity by many suppliers for a centralized, government user. In any event we

do not propose in this writing the details of this organization. This Institute would best be formulated, NACOA believes, through the legislative process.

In brief: finding that the national purpose would be served by the establishment of a modest organization to stimulate more foresighted development of ocean technology than now occurs despite accelerating national activity in the oceans, we recommend there be established an *Institute for Engineering Research in the Oceans*

Whose function it would be to:

- Develop standards which presently, in ocean engineering, lag other fields.
- Fund good ideas in meeting basic engineering needs to the point where they could generate support on their merit or fade away on their lack of it.
- Improve technical transfer and professional communications in ocean engineering.
- Oversee the no-man's land between performing in the oceans and trying to describe and understand it.
- Provide seed money to develop good ideas (but not demonstration projects) before a certain market exists.

t is questionable
hether even a
emonstration will
[illegible] our conservative
marine
community

We suggest a size of:

- About 150 professionals with the technical competence to follow as well as lead, perform as well as monitor.

And a budget of:

- About \$5, \$15, and \$25 million per year (at full strength), more than half of which would be for outside grants and contracts.

Reporting to:

- The Administrator of NOAA as focal agent for marine affairs and Federal Coordinator for Marine Sciences and Technology.

This proposal is a step deeper into commitment to ocean engineering than was recommended in our Second Annual Report where it was suggested that a Federal Coordinator of Marine Technology Development be appointed who would at least assist in the transfer of information from the Navy into the civilian sector. Having looked into the matter with some care, the panel feels that minimum step would be insufficient even though beneficial. Another alternative—to await the effects of the stronger focus for marine affairs to be achieved by government reorganization as NACOA recommended in its Annual Report—would simply delay things, for ocean engineering efforts would have to be concentrated even there in some similar fashion.

What we propose here is not a general solution for marine affairs, but a specific one for ocean engineering. The exact form which it takes is less essential than that it pioneer in ocean engineering and scout out approaches to the civilian engineering problems which we will face tomorrow.

The memorandum we forward expresses those views in somewhat more detail and gives the general argument by which they were reached. The memorandum has been considered by the National Advisory Committee on Oceans and Atmosphere in full and approved by them. It is with pleasure that I forward it.

Sincerely,

/s/William A. Nierenberg

WILLIAM A. NIERENBERG
Chairman

Memorandum Report by the Ocean Engineering Panel

of the
National
Advisory
Committee on
Oceans and
Atmosphere

Engineering in the Ocean

INTRODUCTION

Modern technology is creating a dilemma for engineering by imposing on it precise demands for information on, and understanding of, complicated physical characteristics without relaxing the practical constraints of economics, schedule, and purpose. This dilemma poses especially difficult choices in the oceans where a harsh environment offers severe technical and economic limitations to gaining this technological information.

The civilian effort in ocean engineering both public and private appears to be undersupported in view of the rapid expansion of activities in the ocean and little or no reserve of technology to provide the technical alternatives to meet the requirements which thus develop. Use of the oceans is expanding faster than is the knowledge being provided to support it. While the difference in rates of growth may be temporary, it exists now, and creates a gap. That is why the lack of a conscious effort to do something about it on a national scale is troublesome.

Recognition of this gap is not new, of course, as many previous studies have testified, but almost all these reports suffered from a skeptical reception because the ocean engineering needs were defined so broadly they promised to be costly without promising any obvious results. The panel determined to avoid the general and look for the specific.

It is our purpose in this brief memorandum report to state the task as we saw it, describe our approach, recount what we found, and recommend a course of action we propose be followed.

THE TASK FROM THE SECRETARY

The task suggested by the Secretary of Commerce * was to survey the national civilian needs in ocean engineering, define the specific applications which should be undertaken, suggest the relative roles of industry and government, and recommend how government effort might be applied if other than is now the case.

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* See Attachment A, Letter to Chairman, NACOA, from the Secretary of Commerce, 21 Aug '73.

THE APPROACH BY THE PANEL

Studies already undertaken were reviewed. Staff interviewed many active practitioners in marine affairs in government, in industry, in the oceanographic research community, and at universities, and reported to the panel on what they had been told. This memorandum has been prepared on the basis of what was learned.

FINDINGS: Introduction

The panel learned that there are many specific tasks necessary to the development of ocean engineering which need doing but no general agreement exists as to what, specifically, ought to be done first. No area of ocean technology stands out as critical yet totally neglected.

This could be interpreted as reassuring evidence of normal progress. But the panel feels there is a contributory cause to this drift which is not normal. The contributory cause is the expense of working in the ocean which occurs partly because of the nature of ocean engineering, partly because of the way we go about doing it. The inherent reasons are straightforward but worth noting. You can't leave something on the ocean's surface without mooring it; then, how long it remains there is uncertain. You can't put something on the bottom and find it easily when you come back. It is difficult in the ocean to see and touch what you work with. In addition to the extremes of weather over water, the physical, chemical, and biological effects of water on materials, instruments, and constructions are in general so much more extreme than they are on land, it costs extra even for impermanence. Furthermore gear can't exist except as part of a "system" which means that every upward adjustment in requirements balloons through a whole chain of inter-connected parts. Fighting cost, reliability, and weight at the same time means something has to give. It is usually all three. To top off the expensiveness brought on by the nature of the work, we characteristically add expense unnecessarily by a cut-and-try approach to complex system development in which we fail to work on components separately in advance and suffer further disadvantage in the use of otherwise suitable materials because of marine fouling, stress corrosion, etc.

This matter of cost has a major influence on what can or cannot get done. Further, it involves the important side effect of making it tempting to let someone else do it—or at least pay for it. Working out all the details in advance is expensive and time consuming and so rather more risk is accepted in groping forward. Or one looks to someone else to work things out. In any event many things which people or organizations would normally do for themselves are put on a wish list instead.

The panel's hope was to find a consensus on several critical needs, that is, several items on everybody's wish list, the lack of whose fulfillment was choking progress, and then ascertain whether government support had a role to play and suggest how it might be done.

FINDINGS: Sector Viewpoints

We had expected that government, industry, and the research community would exhibit needs common to their own sector but reflect separate sector interests, and their viewpoints would therefore be somewhat different. They are, and we will attempt to describe them briefly (despite the obvious danger of generalizing about specifics) because these viewpoints illuminate differing approaches to the specific tasks mentioned.

(a) *Government* tasks are so endless, the requirements for program and budget justification so detailed, it was not surprising that ready-made plans exist to take ocean engineering one more step in about any direction named. The price however is a somewhat sluggish responsiveness to new problems and there seems not yet to have emerged forward-looking definition of what needs to be done, in the offshore zone in particular, with regard to ocean engineering aspects of multiple use, regulation, safety, environmental protection, and the like.

(b) *Industry* exhibited a wider range and greater diversity of approaches on what needed doing than did the other sectors. This was reflected especially in the differences of opinion on what industry would like government to do, and what it wishes to reserve to itself. The oil industry has the incentive and the wherewithal to tackle brute-force almost any ocean problem it runs into, but it needs better environmental data. People who build submersibles, on the other hand, would like to see Government programs which use submersibles, even if the direct results are somewhat intangible. Government responsibility is apt to be defined broadly by most as the need for a technological basis—materials research, for example, or general investigations in soil mechanics, or structure loading, or sub-surface nuclear power, or in waste-management in coastal areas. But the economics of it look somewhat different from different vantage points.

(c) The research sector, to lump the oceanographic and university ocean engineering communities, are more of one mind. With only minor variations they stress the theme of continuity, facility support, and receptiveness to a longer view than immediate applicability.

What is common to all sectors then is the judgement that not enough ocean technology is on the shelf, that learning as you go may be the only way to get things done now, but that it is not the best way because it means re-inventing the wheel or basing decisions on expediency which comes back to haunt you later. A little foresight would help a lot in many areas.

FINDINGS: Civilian Ocean Engineering Needs

We did not cover the entire field of ocean engineering in detail for we had neither the resources nor the desire to make a complete survey. We did not seek to find out why U.S. fishing vessels buy Swedish sonars, or why Japanese build bigger tankers. We accepted the judgment that American oil technology is the reserve on which all the world draws, that the U.S. Navy deep submergence capability is unparalled, and that this won't keep on forever if we simply rest on our laurels. We felt that if we sought specifics where we could find them, a strong common trend would probably show up even in a partial sample if it existed.*

Attachment B samples the extensive collections of specifics collected by others. We did not try to compete with these studies. The specifics we did find independently were, in general, not very different from the rather more thorough surveys sampled in the attachment. As with these studies, we found no consensus or major imperatives. Unwillingness to invest effort in anything unless it is immediately needed—at which point it is often too late—seemed to be a root cause of many of the problems but that isn't new. Systems failed because the components had not been thoroughly tested. There was no time—or taste—for a disciplined engineering approach.

Engineering needs exist in such areas as offshore pipelaying, underwater storage tanks, mooring systems, oil spill prevention, dredging, resource recovery, environmental studies, and *adequate component testing of ocean engineering systems before deployment to lower the failure rate, which is high.*

For specific applications the panel's attention was drawn to the need for reliable underwater connectors, subsurface bench marks, nonfouling transducers, and meso-scale current measurements.

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* Special thanks are due to the Sea Floor Engineering Committee of the Marine Board of the National Academy of Engineering for its courtesy in welcoming staff to its deliberations. They are still in progress, in the course of a two-year effort supported by the National Science Foundation, to define the precision with which characteristics of the sea floor and structures within and upon it are known, and the precision with which they should be known. This effort differs from being merely another tabulation in that it is more quantitative and is a step in the direction of standardization.

In all instances, the panel pressed for priority. "What would you do first?" In response to this, specific goals (not specific ocean engineering applications) were usually offered: The panel was offered not priorities, but selection schemes to find them. Criteria such as urgency, responsibility, return vs cost, multiplier effect, and impact were suggested. The relation to energy was offered as a selection device which would imply emphasis on exploration, surveying, offshore federal expertise in drilling and harvesting, information to get offshore plants on line faster, power-plant siting, subsurface soil mechanics, loading factors on structures from wind, wave, and current, and energy sources (oil, wind, wave, current).

Instrumentation was another area to draw attention, in particular monitoring gear, satisfactory subsurface instrumentation, instruments for tidal measurements, wave heights, and surveys. Suggestions were made that user needs would indicate priority, such as those for shipping, petroleum, minerals, construction, recreation, national security, and ocean sciences. Bold pilot projects in energy discovery were suggested from which ocean engineering priorities would develop—and so forth.

A persuasive case was made for the critical importance of materials research, especially as materials are affected by fatigue under cyclical loading, and in stress corrosion where the chemical action of seawater affects materials in an unusual way.

Nevertheless, the common trend did not turn out to be a specific high priority application. Instead it was the apparent inability to choose what ought to be done first. Despite an almost universal if poorly defined distress at not doing things that ought to be done there was instead a helter-skelter looking in all different directions and reaching for schemes to pick winners. Specific application of ocean engineering to civilian needs appeared trivial as candidates for a national effort, yet the more general suggestions for enhancement of ocean engineering capability sounded poorly thought out, open-ended in cost, and groping for support.

It was also evident that there is no natural government sponsor for the general support of civilian ocean engineering needs. Of the government agencies with direct interest in the oceans, only the Navy has responsibility for pursuing advanced technology directly; other agencies, such as the Department of Interior, NOAA, the Coast Guard, etc. relate the ocean engineering needs to their service requirements and so no one has a broad oversight.

FINDINGS: Summary

The marine implications of the over-riding need for the U.S. to decrease its dependence on other nations for what is critical to its own existence are too important for the United States to let drift.

There is an "ocean engineering problem"—it won't go away even though general goals are unconvincing because their costs are too open-ended and separate specific goals don't win enough votes.

Complaints from those with whom the panel made contact proved to be less along the line of specific technological deficiencies than they were organizational in nature. There was concern for the lack of understanding of the need for ocean engineering until it proved late and expensive to correct what foresight might have prevented. There was concern for the lack of continuity in ocean engineering development which meant inefficient, stop-start investigations. There was concern for the lack of meso-scale activity mid-range in size, mid-range in time, and mid-range in money. There was concern about the lack of timely communication of data that did exist.

The panel's findings were:

- The ground has been well-ploughed.
- There is no question but that there are things to do in ocean engineering but too many to do all at once.
- There is no general agreement on what projects or programs ought to be done first.
- This may be because no one thing ought to be worked on first and many ought to be worked on simultaneously.
- Drifting along until we hit a snag seems hardly the useful way to go.

On the relative roles of government and industry in ocean engineering—there seems to be agreement in principle. It is: The cost of ocean-engineering research and development is to be borne by those who would benefit from it. If the development is for a specific operation with specific users, the costs should be assumed by the operator and reflected in the price of the product or charge for service, or, if there are many and disparate operations by whose use the public is generally benefited, the cost should be borne by the general taxpayer and requests for funding must compete with other and unrelated demands.

The hitch comes in deciding whether a particular development fits one definition or the other. The ambiguities seem to arise in three ways: (1) when the direct benefits are hard to figure, (2) when the benefits are twice-removed, i.e., when the direct results might stimulate benefits but their nature is not directly foreseeable, and (3) when differing conception of the detail, the risks, and the time-to-payoff raises the argument of who should pay for the middle stages. This is especially complex because the expenditure of government funds in the early high-risk stages of development leads to a government interest in later stages where industry would otherwise prefer to go it alone. It is

the implication of continued government involvement (in addition to the normal divergence of opinion on regulation and monitoring) which leads to such differences of opinion by industry on government's role in a new field. It seems to depend a lot on how much is available to be put at risk in the early stages.

The panel sees no way out except by deciding each case on its own merits, for industry is not uniform in its attitudes and its needs; its relationships with government vary.

CONCLUSION AND RECOMMENDATIONS

Short-range ocean engineering problems and applications are being attacked and solved by industry if they otherwise would block operations, but the solutions are often expedient and expensive in the long run because they have been worked out in a hurry. A long-range program for supplying background information on the oceans exists in NOAA, though it is bound to fall short of satisfying everybody's requirements because it is expensive in the detail and the precise characteristics sufficient to keep everybody happy.

But the extensive lists of engineering to be done in the oceans include whole classes of problems in materials, techniques, engineering characteristics, and instrumentation whose solutions, if anticipated, could save time, and money, and possible environmental strain, if tackled now. They seem ripe for government encouragement if only of a limited sort. Since the candidates for support are so numerous, as are the selection schemes themselves, the panel came to the conclusion that what is needed is wide-ranging stimulation of the field to provide technical alternatives, with demonstration technology left to others once particular ideas prove out.

This conclusion was not independent or isolated. Two organizational examples of what kind of organization people in ocean engineering would like to see active kept cropping up: (1) the Office of Naval Research through its twenty-five years history and the role it has played in providing continuity to the support of basic research and in paving the way for the National Science Foundation, and (2) the National Advisory Committee on Aeronautics and the role it played in welding research, industrial, and governmental efforts in aeronautical engineering. Both were outstanding in stimulating progress in highly technical areas—the one in basic and the other in applied science. The heart of the matter is that support was offered for good ideas, not for predictable results.

However, neither the ONR nor the NACA concepts apply to ocean engineering today. ONR was launched to preserve the Navy-University relationship at the end of the vigorous fast-moving and successful

cooperation in research for weapon systems induced by World War II. And money was available. The NACA helped bring on the age of the airplane, it was an integrating device to harness what otherwise was scattered or partial. The conditions which made these agencies so singularly appropriate do not exist for ocean engineering today. A relationship has to be established outside of the Navy, not preserved. The analogy between the atmosphere's heights and the ocean's depths for those to whom ocean program seemed as impelling as a space program has been spectacularly unconvincing. And no war-end millions (with which ONR was launched) are there to be used.

But, if a catalyst to stimulate engineering in the oceans is needed since a programmatic solution does not seem sensible, there is no good reason why results similar to those produced by ONR and NACA could not be achieved, albeit in a somewhat different way. An organization is therefore proposed whose function it would be to provide technology-gathering and technology transfer, to stimulate industrial efficiency and development in the oceans, to work on the ocean's problems a few years ahead, to back good people and good ideas, and to set standards for and back-up the regulators and the issuers of permits and safety certifications in the oceans.

The panel therefore recommends an Institute for Engineering Research in the Oceans reporting to the Administrator of NOAA as the proper focus for marine affairs, but independent of the mainline components in that agency as too limiting, too confining for an organization which is to serve users in a broad range of government, industry, and research.

There are a number of government agencies whose need for ocean engineering expertise make them possible hosts for such an Institute such as the Department of Interior, the Navy, the Coast Guard, EPA, the National Scicence Foundation, the National Bureau of Standards, NASA, etc. But as we stated earlier, none of the civilian agencies presently has a responsibility for *general* oversight of national ocean engineering needs. NOAA, as the focus for marine affairs, is the most appropriate agency to hold in trust, so to speak, an Institute which would be geared to encourage needed progress in ocean engineering activities.

This Institute could not easily be part of the Sea Grant Program for it is essential that this Institute work with all types of organizations and individual practitioners and that it conduct its own in-house research. It must also be in a position to develop the special relationship with the Navy which would facilitate transfer of what can and should be transferred to the civilian sector from the Navy's extensive store of ocean engineering expertise. An organization close in its management of research in support of standard-setting functions in ocean engineering

to that suggested for the Institute is Det Norske Veritas, a Norwegian entity that certifies shipping (and offshore platforms) and is most highly regarded for its professional competence and the manner in which its setting of standards is backed by research. This organization is funded by those whom it services.

An Institute similar to one of the National Institutes of Health would be a closer U.S. analogy in its manner of operations to what the panel has in mind than the organization which grew up to serve the Department of Defense in the fifties and sixties. the DOD institutes gathered technical expertise from all over the country to assist one or two government-agency users. The Institute of Engineering Research in the Ocean would have the purpose of stimulating and contributing to activity in ocean engineering of interest to users dispersed throughout the nation--industry, federal, state, and local government, research institutions, etc. The customer is he who must work in the ocean, not a government agency. or might best

The goal of the Institute would be to stimulate useful activities of others, which means it must possess the competence to judge what seems right for the field and have the dollars to back its judgement. It must have a necessary technical competence of its own, and be in a position to offer support directly or use matching funds to take advantage of local judgement on priority of importance. Some form of recovery of portions of the matching funds, on the basis of performance, or of results, could be offered as incentive (similar to the practice of the Defense Department in stimulating independent R&D along lines of DOD interest). The form and nature of the arrangement would clearly have to be worked out carefully with the utmost regard for keeping the Institute responsive, catalytic, technically aggressive, but reasonably controlled in the amount and the support it can offer. An essential function would be to improve timely technical publications and communication which is distressingly poor in ocean engineering today. A Board of Governors, representative of industry, the universities, and government is necessary to oversee the general course taken by the Institute and to provide a powerful means for keeping the Institute sensitive to changing national requirements and for keeping it technically competitive.

The panel estimates that for such an Institute to develop recognized technical excellence in ocean engineering, it must grow to about 150 professionals. To develop input from the nation at large and impact on the field it should disburse out-of-house at least one and a half times the funds it uses itself. This implies a start-up schedule for funding the first three years of $5 and $15 million to level off at $25 million per annum although the nature of the facilities which would be required or used would have significant bearing on the rate of growth.

The panel is under the impression that the creation of such an Institute could best be accomplished by the legislative process during which the details of its composition, procedure for operation, and immediate tasks would be worked out in detail as a result of the broadest possible input from interested parties. It believes that the legislation should provide for an early review starting two years after startup to monitor the course the Institute is taking and a major review in five years to ascertain the Institute's contribution and the value of continuing it. The panel sees no conflict between its requirement for excellence and its suggestion that it come up to speed in a few years. Five years is a long time in which to make a case.

Recapitulation

To the Secretary's Question: What specific civilian ocean engineering applications to meet national requirements are not now being pursued? No major area seems to be without some attention, but it is less a question of specifics than of sluggishness in response to a whole category of mid-range problems in materials, techniques, and engineering characteristics, many having to do with responding forcefully to questions regarding environmental factors.

To the Secretary's Question: What are the relative roles of government and industry? Broad stimulation of the field by the former and specific development by the latter. If, as a nation, our development of technology in the oceans seems to be lagging (for which there is evidence, it is said, in the more rapid progress being made by other nations), it is not unreasonable to charge the Federal Government with trying to do something about it.

To the Secretary's Question: What do you recommend be done about it? We recommend the establishment of an Institute for Engineering Research in the Oceans, to report to the Administrator of NOAA, whose mission it would be to catalyze activity in the mid-range term 3 to 5 years ahead. This is not the only beneficial step which might be taken, but we believe it to be that most promising in effectiveness.

An Institute for Engineering Research with modest funds to expend in- and out-of-house should prove its own usefulness in about five years or rightfully sink out of sight. It would not be a sluice for funds nor would it have to wait on agreement on stated national goals and objectives—it would take off on those implicitly agreed to.

Attachments

Attachment A

THE SECRETARY OF COMMERCE
Washington, D.C. 20230

August 21, 1973

DR. WILLIAM A. NIERENBERG
Chairman, National Advisory Committee
on Oceans and Atmosphere
Washington, D.C. 20230

Dear Dr. Nierenberg:

The National Advisory Committee on Oceans and Atmosphere (NACOA) has commented extensively on the Nation's civil ocean engineering program in its second annual report. It has made recommendations for improved coordination of the Nation's ocean engineering activities and has suggested a number of areas for emphasis.

I believe that ocean engineering is one of the important elements in the Nation's future posture in ocean affairs. What is needed is an analysis and documentation of the requirements for an ocean engineering effort by the civil agencies of the Federal Government. There are many key questions about a civil ocean engineering program that need answers, such as:

(a) What specific ocean engineering applications should be addressed by a Federal program to meet national requirements and what are these requirements?

(b) What are the benefits that can be expected from Federal investments in specific types of ocean engineering?

(c) To what extent should the Federal Government engage in and support civil ocean engineering activities?

(d) How should such support be provided in those instances where Federal Government effort is clearly warranted?

(e) What should be the relative roles of private industry and the Federal Government in fostering ocean engineering?

The above are all key questions, answers to which would be valuable in planning a civil ocean engineering effort.

The National Advisory Committee on Oceans and Atmosphere could be of great help to the Federal Government in organizing and carrying out an analysis directed at answering the types of questions that I have listed above. These questions should not be regarded as the only ones that are pertinent but only typical of those that require answers.

Accordingly, I am requesting that the National Advisory Committee on Oceans and Atmosphere undertake such a study and report to me on its results.

Sincerely,

/s/Frederick B. Dent

FREDERICK B. DENT
Secretary of Commerce

Attachment B

A Sampling of Civilian Ocean Engineering Needs

The Ocean Engineering panel was well aware that it was not the first group to take on an evaluation of national civilian ocean engineering needs and instructed staff to seek out previous studies with bearing on the task before it. A number of these previous studies turned out to be surprisingly explicit. A sampling from four reports covering a span of seven years is included in this attachment to demonstrate the care and detail with which ocean engineering needs have been specified. Excerpts from the Stratton Commission Report are not included partly because it is so well known, and partly because it generalized these needs into targets of national capability so that the underpinning specifics are not otherwise easily summarized.

It was the existence of reports such as these from which the attached concepts have been made which brought the panel to the early conclusion that it would not suit its own purpose to provide another set of what it would be nice to know about ocean engineering. Rather it needed to know what it would be good to do first of that which was already known.

Example I
1967

Excerpted from

> "Underwater Technology Requirements for Non-Military Ocean Missions" prepared for National Council on Marine Resources and Engineering Development by Southwest Research Institute, 1967.

The manner in which this 1967 report classified the areas of underwater technology and related basic engineering, engineering components, to general systems, and operations to ocean missions is shown in Table 3.1 and Figures 3.2, and 3.3 immediately following.

Priorities and the relative roles of industry and government were also treated in Table 9.1, also attached.

Table 3.1

Areas of Underwater Technology

Basic Engineering
- Coastal and Oceanic Hydrodynamics
  - Wave motion, force, spectra
  - Tides, seiches, surges, tsunamis
  - Reflection, refraction, diffraction
  - Currents. Turbulence and diffusion
  - Sediment erosion, transport, deposition
- Underwater Soil Mechanics
  - Physical properties; in situ and laboratory
  - Sampling. Testing. Site surveys
  - Bearing capacity. Foundation settlement
  - Anchoring. Breakout. Penetration
  - Scour. Stabilization. Slope stability
- Materials Engineering
- Structural Mechanics
- Mechanical and Electrical Sciences
- Naval Architecture and Marine Engineering

Engineering Components
- Instrumentation Systems
  - Navigation, positioning, communications
  - Observations, recording, measurements, sampling
- Power Sources
  - Batteries. Fuel cells
  - Radioisotope. Nuclear
  - Chemical dynamic. Closed cycle diesel
- Equipment, Tools, Devices
  - Motors, pumps, propulsion units, controls
  - Fittings, connectors, penetrations, seals
  - Tools: cutting, hammering, torquing, welding
  - Manipulators. Remote control systems
- Life Support Systems
  - Submersibles, habitats, divers

General Systems and Operations (multimission applications)
- Submersible Vehicles
  - Manned and unmanned
  - Tethered, untethered, towed
  - Bottom crawlers
- Mooring Systems
  - Anchor and cable
  - Dynamic anchoring

- Underwater Structures and Installations
  - Platforms
  - Petroleum production installations
  - Habitats, observatories, laboratories
  - Power generating and processing plants
- Man-in-the-Sea Operations
  - Free and hard hat diving
  - Saturation diving systems
  - Working and living underwater
- Underwater Construction Methods and Equipment
  - Dredging. Trenching
  - Piles. Caissons
  - Underwater fabrication, maintenance, inspection
  - Pipelines
  - Subaqueous tunnels

Mission-Oriented Technological Areas

- Fisheries Technology
  - Support of marine biology research
  - Location, tracking, identification
  - Concentration, control, harvesting
  - Modification of environment
  - Support of mariculture
- Petroleum Drilling and Production
  - Drilling platforms. Mobile rigs
  - Blow-out preventers. Marine conductors. Casing strings
  - Production platforms. Subsea completion systems
  - Underwater storage tanks. Gathering lines
- Ocean Mining
  - Exploration and evaluation
  - Extraction, processing, transportation
- Shoreline Modification and Island Building
  - Shoreline structures and construction methods
  - Beach erosion, transport, deposition, silting control
  - Land fills. Island building
- Underwater Technology Supporting Pollution Control and Waste Disposal
  - Standards and tolerance limits
  - Monitoring and sampling systems
  - Dispersion of wastes (industrial, mining, radioactive)
  - Removal of discharged oil
- Search and Salvage Methods and Equipment
  - Search and identification
  - Attachment, lifting, flotation
  - Recovery of cargo and equipment
  - Removal of debris

Figure 3.2

Relation of Basic Engineering and Engineering Components to General Systems and Operations and Mission-Oriented Technological Areas

Basic Engineering and Engineering Components	General Systems and Operations and Mission-Oriented Technological Areas						
	Coastal and Oceanic Hydrodynamics	Underwater Soil Mechanics	Materials Engineering	Instrumentation Systems	Power Sources	Equipment, Tools, Devices	Life Support Systems
Submersible Vehicles			X	X	X	X	X
Mooring Systems	X	X	X		X		
UW Structures and Installations	X	X	X	X	X	X	X
Man-in-the-Sea Operations			X	X	X	X	X
Underwater Construction	X	X	X	X	X	X	X
Fisheries Technology			X	X			
Petroleum Drilling and Production	X		X	X	X	X	
Ocean Mining	X	X	X	X	X	X	
Shoreline Modification and Island Building	X	X	X				
Pollution Control, Waste Disposal	X			X			
Search and Salvage		X	X	X	X	X	

Note: All of engineering areas (basic and components) apply to a certain extent to each of the general and mission-oriented areas. The X denotes only the more important applications.

Figure 3.3
Relation of General Systems and Operations to Ocean Missions

Missions	Systems and Operations: Submersible Vehicles	Mooring Systems	UW Structures and Installations	Man-in-the-Sea Operations	Underwater Construction
Seafood Developments	X	X	X		X
Recovery of Petroleum	X	X	X	X	X
Recovery of Minerals and Chemicals	X	X	X	X	X
Underwater Transportation	X		X		X
Coastal Zone Development		X		X	X
Pollution Control and Waste Disposal		X			
Salvage and Recovery	X	X		X	X
Weather Prediction and Modification		X	X		
Exploration and Research	X	X	X		

Note: X denotes ocean mission for which a given system and operation will have an application in present or future developments.

Table 9.1
Areas of Underwater Technology

	Area	R & D Effort Relative to Present Rate: Greatly Accelerated	Some Increase	Present Rate Adequate	Initiative for Developments: Primarily Government				Primarily Industry	* Suggested Government Action	* Priorities for New Government Action
Basic Engineering	1. Coastal & Oceanic Hydrodynamics	●			▼					A	1
	2. Underwater Soil Mechanics	●			▼					A	1
	3. Materials Engineering		●				▼			B	2
Engineering Components	4. Instrumentation Systems Navigation, Communications, Bathymetry, Observations, Measurements, Sampling	●					▼			A	1
	5. Power Sources	●				▼				B	1
	6. Equipment, Tools, Devices		●					▼		B	2
	7. Life Support Systems			●			▼			C	
General Systems & Operations	8. Submersible Vehicles	●					▼			B	2
	9. Mooring Systems		●				▼			C	
	10. Underwater Structures & Installations		●					▼		B	3
	11. Man-in-the-Sea Operations			●			▼			C	
	12. Underwater Construction										
	a. Dredging, Trenching			●				▼		C	
	b. Piles, Caissons			●					▼	C	
	c. Pipelines			●					▼	C	
	d. Tunnels		●				▼			B	3
	e. UW Fabrication, Maintenance, Inspection	●						▼		B	2
Mission-Oriented Technological Areas	13. Fisheries Technology										
	a. Support of Marine Biological Research	●			▼					B	1
	b. Harvesting, Mariculture		●				▼			C	
	14. Petroleum Drilling & Production		●						▼	C	
	15. Ocean Mining										
	a. Exploration and Evaluation	●				▼				B	1
	b. Extraction and Processing		●					▼		C	
	16. Shoreline Modifications, Island Building	●					▼			B	2
	17. Support of Pollution Control & Waste Disposal		●			▼				B	2
	18. Salvage Methods & Equipment		●				▼			B	3

*Table 9.1 is a digest of the summary Chapter 9 of this report and conditions under which evaluations were made are given there with some care. The stated judgements are clear with the exceptions of symbols under government action required and priorities which may be paraphrased as follows:

A. New or greatly expanded physical facilities required.

B. Management and coordination of existing programs needs strengthening.

C. Present arrangements seem OK.

The criteria for priorities were commonality, urgency, and criticality.

Example II
1972

Excerpted from

> "Toward fulfillment of a National Ocean Commitment," A Report of the Marine Board, National Academy of Engineering, Washington, D.C., 1972.

The National Academy of Engineering Report "Toward Fulfillment of a National Ocean Commitment" contains a great number of suggestions and recommendations for work in ocean engineering. The subjects covered give the shape of the Report's content and a brief paraphrase or outline is given below. In some areas the guidelines for proceeding are given in extraordinary detail.

MARINE TRANSPORTATION

Marine Speed Gap: 30 to 200 knots not now covered.

Ship Operating Problems: High cost of domestic construction; high operating costs; trade route problems; regulation and cargo preference; conferences, etc.

Ship Building: Mixed Navy and Civilian construction sub-optimal.

Merchant Marine: Underutilization of available technology; unattended power plants; unattended ships; design, coating, propulsion, anti-fouling, routing to avoid weather.

NEW VEHICLES

Hydrofoil, air cushion, semi-submersibles.

LIVING RESOURCES

Fish location; preservation aboard harvesting vessel; processing in general; aquaculture, contaminants.

NON-LIVING RESOURCES

Recovery of minerals from deep sea floor.

ENVIRONMENTAL ENHANCEMENT

Recreation, urbanization, power, coastal works, water resources.

EXPLORATION AND SURVEYING

Fish, fuels, bottoms, navigation, etc.

CONSTRUCTION AND CIVIL WORKS

Effects of the Ocean Environment on Construction

Bottom Aspects: Littoral drift and mud slides; bottom scour; mapping and bathymetry, soil mechanics, geology, earthquakes.

Air-Sea Interface: Wind-induced waves, tsunamis, sea-ice and icebergs, tidal motions and storm surges, weather forecasting.

Sea-Water Characteristics: Pressure effects, temperature; currents, biological effects, corrosion effects, overall environmental effects.

Construction and Civil Works in the Ocean

Systems Approach: Effect on the Environment

Ports and Harbors: Future requirements, planning and design, port authorities.

Coastal Engineering

Facility Equipment

Offshore Construction: New land; floating platform; artificial islands; offshore platforms and submerged buoyant structures; mineral exploration and exploitation; pipelines; tunnels; and habitats.

Materials and Fabrication Methods: Material needs; fabrication methods.

Exploration and Development Programs

Instrumentation and Testing

Oceanographic Data Acquisition

Models of Ocean Environment

Construction Material and Fabrication Methods Development

VEHICLES AND PLATFORMS

Introduction

Ocean Exploration Needs

Management Responsibility

Time Scales

Study Methodology

Analysis of Tasks for Vehicles and Platforms

Critical Task Area: Launch; operation; navigation; communication; sensing/processing; work.

Limitation in Technology

PRINCIPAL TECHNOLOGY REQUIREMENTS

Structure/Material: Pressure; hull; fabrication techniques; coatings.

Mechanical Interfaces: pressure hull bolted joints, exostructure connections; deep-depth emergency escape; hatch sealing at extended depth; supplemental buoyancy material.

Power Sources: Batteries; fuel cells; nuclear; waste-heat dissipation; power-source technology.

Electrical System: Connectors; conditioning equipment; hull penetration; power cables.

Machinery and Equipment: Hi-pressure seawater pumps and valves; hydraulic fluids and connectors; deep-depth ballast tank blow system; propulsion and control system; winches and cables.

Data System: Viewing; signal processing; sensing; undersea navigation; underwater communication.

Work System Technology: Manipulator systems; lock-out systems; sediment stabilization systems.

Support System: Surface tanking system; submerged support; life-support system.

Man in the Sea, Instrumentation, Navigation, and Communications

These chapters all have large lists.

Example III
1973

Excerpted from

"Report on Marine Technology" by a Panel of the Science Research Council, London, 1973, p. 28-43.

APPENDIX 3 Recommended Research Areas by Field Reference Number

(Asterisk denotes high priority)

Field Reference 01

SHIP DESIGN - STRUCTURAL AND STRESS ANALYSIS

The response of structures to static and dynamic loads is considered in this section. Both static and dynamic behaviour is of concern especially where non-traditional materials are considered, for example, ferro-concrete. The methods of obtaining dynamic responses are of interest, where new techniques are being applied, such as the use of finite elements in propeller blade vibration calculations and in ship vibration calculations where the ship is treated as a three-dimensional stiffened plate structure instead of the usually assumed beam simplification.

A better understanding of fatigue and crack propagation as experienced by ship structures is required to provide information for efficient and safe detail design.

Methods of analysing and designing 'open-deck' ships for torsional loads are required, and these should take into account variation of cross-sectional properties along the length of the ship.

The response of ships' structures to impulsive loading is of concern from the point of view of preventing damage locally and also from the point of view of transmission of periodic forces which may cause unacceptable forced and resonant vibrations.

Recommended Topics

The design of a ferro-cement, pre-stressed concrete hull with technical and economic considerations taken into account.

The application of finite element techniques to the calculation of vibration responses of ships' hulls.

The assessment of the vibration characteristics of large marine propellers.

The assessment of structural response to impulsive loading.

A study of fatigue and crack propagation in ships' structures to provide design guidance.

The analysis and design of 'open-deck' ships under torsional load.

Field Reference 02

SHIP DESIGN - PROPULSION

The topics listed below range from the very specific to the rather general and, undoubtedly, the general ones would require specification in greater detail before they could be supported with confidence.

Apart from the very general items there appears to be very little – if any – overlap with work already underway. This is not, perhaps, very surprising as most of the undermentioned topics have been suggested by non-educational institutions.

Recommended Topics

Standby steam superheating by induction heating at normal supply frequency.

Investigation of increased steam speeds in saturated steam lines.

Effects of steam wetness on condensing heat transfer.

Design of boilers to accept rapid changes in steam demand.

Design of condensers.

Investigation of the future use of supercharged boilers in marine installations.

* The effect of fluctuating torques in the gearing of medium speed marine diesel engine systems.

Development of theoretical methods of solution for the determination of natural frequences and normal elastic curves of heavy shaft marine propulsion systems.

Strength and vibration characteristics of main engine seats at higher powers.

Fundamental design procedure for steam bearings.

Aeration of lubricating oil in geared turbine systems.

Techno-economic studies of choice of main machinery system for factory trawlers including A.C. and D.C. electrics, hydraulics, C.P. and fixed propellers as means of transmitting power.

Production of data for, and preparation of, a series of propeller performance charts especially for (a) C.P. propellers, (b) shrouded propellers. (c) all propellers at speeds of advance associated with towing of fishing gear.

Analysis of vibration of ducted propellers.

Aerodynamic design of large 3D diffusers in gas turbine uptake and downtake systems.

Removal of waterborne salt from air in gas turbine intakes.

Coalescer filters – the effects of vibration and throughput of fuel and water.

* Air flows in confined machinery spaces containing supercharged i.c. engines, large electrical machines and men.

* The environment effects of noise in ships.

Computer drawing of pipework.

Field Reference 03

SHIP DESIGN - HYDRODYNAMICS, PERFORMANCE

Recommended Topics

Performance of ducted propellers with hull boundary layer interaction.

Effect of form on the resistance and propulsion of small craft and determination of correlation factors.

Measurement of wave pattern resistance full scale and correlation of same with model.

Development of computational techniques in non-linear wave resistance theory.

Measurement of drag and lateral force components for asymmetric hulls.

Effects of viscosity on wave resistance – theoretical and experimental treatment combining boundary layer and potential theories.

Resistance of trailing side pipes and suction heads of dredgers – variations with configuration and load on sea-bed and sea-bed materials.

Investigation of the characteristics of turbulent wakes (fully immersed bodies).

Study of scale effect on separation, particularly on the after-body of tanker forms.

Laser measurements of velocity, turbulence of boundary layers and rotational wakes at both full scale and model scale.

Physical understanding of flow patterns over different surface curvatures.

An examination of the hydrodynamic laws governing the separation of flow at the stern of a 3D body, leading to the derivation of design rules for bodies of minimum separation.

*Determination of the scale effect of vortices from model to ship size.

*Finite element treatment of hydrodynamic phenomena.

*Research on noise, especially in relation to onset of cavitation, with a view to reduction in noise output of fishing propellers, shafts, etc., in certain frequency bands.

*Investigation of the distribution of bubble streams (generated by the bow wave) around and beneath the hull.

*A study of the hydrodynamic and scaling laws for water currents induced by streams of air bubbles, with the aim of exploiting such currents for use in ship manoeuvring and berthing.

*Physical understanding of skin friction for rough, smooth and chemically treated surfaces in various fluids.

Field Reference 04

SHIP DESIGN - HYDROELASTICITY (INCLUDING FOIL BEHAVIOUR)

Recommended Topics

Studies in propeller excited vibration.

*Control of propeller induced vibration.

Fundamental work on boundary layer theory to predict the distribution of wake velocity over the propeller disc.

Prediction of fluctuations in propeller blade loads due to variation of wake velocity over the propeller disc.

Torque and thrust characteristics for fixed pitch and controllable pitch propellers and interaction with hull under dynamic conditions.

Factors influencing, and control of, wave induced transient vibration.

Understanding of wave excited vibration.

Vibration of surfaces moving through fluid (eg bottom panel of ship).

Causes of cable vibration and its effect upon the drag characteristics of a towed cable both plain and faired, including vortex shedding.

Most of these suggestions emanate from non-university sources and, clearly, propeller induced vibration and wave excited vibration are the favoured areas for future work. From the data supplied it appears that only University College and Newcastle have current work in the field of hydroelasticity, but the degree of detail supplied does not enable much matching to be done with the proposed items. There is probably very little overlap. However, there is some overlap and redundancy in the proposed topics themselves and some could coalesce into single items.

Field Reference 05

SHIP DESIGN - HULL LOADS AND SHIP MOTIONS

Of interest to this section is the derivation of the forces acting on a ship's structure in a seaway. These forces are a result of the passage of waves, the ship motions, and the sloshing of liquid cargo, all of which create pressure forces and may cause impact forces. An accurate definition of these forces is necessary before full advantage can be taken of advances in stress analysis techniques.

Work on ship motions is required to help define underkeel clearance in shallow coastal waters; this is of particular concern to large tankers. The requirement is to define the ship responses of pitch, heave and roll, and the sinkage effect caused by the relative forward motion between the ship and the water. For all these, it will be necessary to take account of the proximity of the sea bottom as it will influence the hydrodynamic damping and added virtual mass associated with ship motions and will also influence the sinkage effect caused by the restricted area of flow under the keel.

Recommended Topics

General and local hydrodynamic loading on ships' structures owing to the effects of wave action, ship motion and liquid cargo.

The determination of added virtual mass and damping for ship shape forms for three-dimensional flow in deep and shallow water.

The determination of underkeel clearance for ships at various speeds in shallow water with a seaway.

The determination of propeller pressure forces and wake forces and moments.

Field Reference 06 (See Field Reference 19)

SHIP DESIGN - MANOEUVRABILITY, STABILITY AND STEERING SYSTEMS

The work of interest to this section is concerned with the manoeuvrability and directional stability of ships and boats, and also the associated optimum automatic steering system. Of immediate interest is steering and manoeuvring in shallow water at slow speeds, as typified by harbour approaches, and a longer term interest is the mathematical description of the motion of a ship with random wave disturbance.

Also considered under this section is transverse stability which requires investigation for fine ship forms travelling at speed in calm water and in a seaway. The effect of speed is to alter the righting ability of a ship and this is further modified by the passage of waves.

Recommended Topics

The development of analytical techniques for the determination, at the design stage, of manoeuvrability and directional stability properties leading to specifications for optimum automatic steering systems.

The determination of manoeuvrability and stability of hydrofoil craft and hovercraft.

The determination of ship manoeuvrability characteristics at slow speeds in shallow water and in channels.

The determination of transverse stability at speed and in a seaway.

Field Reference 07

PLATFORMS AND STRUCTURES AT SEA

Recommended Topics

Foundations

Foundations on various types of sea-bed.

Buoyant foundations.

Effect of structures on erosion and sedimentation.

*Scouring action in vicinity of fixed structures.

Erosion and sand movements around underwater pipes.

Design Loads

Wave forces on pipes and columns.

Properties of random waves and corresponding response of structures.

Full scale measurements on structures.

Estimation of wave forces for structures under tow.

Validity of small scale models in predicting loads on structures.

Structural Design

Rational design criteria for marine structures.

Design loadings for marine structures.

Measurement and comparison of stresses in structures.

Stress levels in 3D joint configurations.

Measuring and Monitoring Equipment

Wave recorder to measure wave spectrum.

Development of improved wave recorders.

*Design of buoy system to measure currents and wave heights.

Data recording and transmission buoys.

Acoustic emission techniques to monitor stresses.

New Concepts

Concrete pontoons, platforms, drilling rigs.

Precast submerged tunnel units and erection gantries.

Ice as a structural component.

Design of breakwater for attachment to legs of platforms.

Devices to protect deep water terminals from surface effects.

Field Reference 08

DESIGN AND CONSTRUCTION OF UNDERWATER PIPELINES

Recommended Topics

Design

Improved weighting techniques less susceptible to damage than the present concrete coating.

*Forces on pipelines due to waves and current.

*Trenching and surface stabilising techniques.

Interaction with Sea-Bed

Effect of structures in causing erosion and sedimentation.

Study of erosion and sand movements and development of stabilising techniques to avoid exposure of underwater pipelines.

Field Reference 09

MATERIALS FOR MARINE APPLICATION

Recommended Topics

Use of Composite Materials and Laminates

eg Glass reinforced plastic

Low density Epoxy

Fatigue strength – bi-axial fatigue behaviour

Toughness

Corrosion Resistant and Animal Growth Resistant Materials,

eg coated steels or naturally passivating steels.

*H.T. Steels

Fatigue in welding details.

Stainless and Low Elongation Steels.

Hydrogen embrittlement.

*Shaft and Seals Materials

Fundamentals of behaviour of materials of different hardness in contact (Application to stern tube seals).

Simulation and assessment of self-lubricating bearing materials.

Gaskets

Ability to maintain sealing properties after serious distortion of mating structure.

*Fire Resistant Materials other than steel or mineral based material.

Welded Structure in Sea Water

Fatigue.

*Fracture Toughness

Fundamental investigations of factors mainly near welded joints in plates.

Field Reference 10

CORROSION AND ANTI-FOULING MEASURES

Recommended Topics

Anti-fouling

Fouling of metals and plastics in coastal waters.

Influence of marine growth on flow resistance of static structures.

*Development of a rubber or plastic skin for ship plates to prevent attachment of marine growth.

Destruction of spore of algae or prevention of sediment other than by poison, e.g. bacteria.

Corrosion

*Corrosion fatigue in relation to off-shore structures.

Development of alternative to blast cleaning for the pre-treatment of welded areas to ensure adequate adhesion of protective coatings.

*Paints

Inter-coat adhesion

Permeability to water and ions.

Extension of cathodic protection to splash zone.

The behaviour of metallic couples under sea-bed conditions, specifically the rate hydrogen evolution, the rate of corrosion and the effect thereon of a covering of sediment containing decaying organic matter.

Field References 11, 12, 13, 21, 22

11 DIVING TECHNOLOGY

12 UNDERWATER HABITATS

13 UNDERWATER POWER PLANT AND TOOLS

21 UNDERWATER VIEWING, PHOTOGRAPHY AND OBJECT LOCATION

22 UNDERWATER COMMUNICATION

Recommended Topics

Improved Diver Work Capability

Development of improved life-support systems and details for shallow, medium and deep depths. These items would include the diving suits themselves (including insulation/heating), decompression chambers, personnel transfer chambers, perhaps underwater habitats (lock-out submersibles), etc. Some fundamental work on basic parameters might be of value, but any system developed must take into account the necessity for it to be economical both to build and operate.

Development of improved underwater communications system for divers between themselves and to the surface. This brings in the need for improved unscrambling devices to counteract helium speech.

Development of greatly improved lighting or other systems to improve visibility underwater, and give the diver 'eyes'. This could include the adaptation, for use underwater, of some methods at present under development for blind people.

Development of improved light-weight navigation and homing systems for divers, both for safety and for search/location/rescue.

Development of a light-weight, reasonable endurance, cheap diver transport vehicle.

Development of improved handling systems for divers, diving systems, equipment, submersibles, habitats, etc. through the air/sea interface in weather up to sea state 5/6 or higher.

*Study and analysis of diver accidents and existing safety regulations, with a view to developing better regulations, codes of practice, training standards and methods,

support and diving equipment, etc. This would require the analysis of such statistics as exist, and research into other accidents which have gone unrecorded in statistics but are available from Coroner's Court reports, insurance archives, the Factory Inspectorate, etc. This work should be done in conjunction with the Medical Research Council Decompression Panel, the Underwater Engineering Group, the Royal Naval Physiological Laboratory and any others already involved in certain parts of this work.

The use of lasers and other possible methods in the improvement of communications and viewing underwater.

The development of a 'black box' to be carried by divers, with a pressure and temperature recorder versus time, to be used in the analysis of existing work practices and the correct use of decompression schedules. This work should be done in conjunction with the Medical Research Council Decompression Panel at Newcastle (Professor Walder), which has already made some progress in the development of such a monitoring unit.

A study of the design and dimensions of the mating assemblies of one-man and large-scale decompression chambers throughout the country, including those in naval establishments, to try and find the best design and recommend standard dimensions, to permit the mating of portable chambers with the major facilities in various centres, so permitting the transfer of divers under pressure. This study should also result in the preparation of a complete list of available facilities throughout the country.

Underwater Work

Development of underwater power sources.

*Development of underwater acoustics for surveying, navigation, search and location, communications, control, etc.

Development of improved underwater television and photographic systems for control of underwater work, surveying, etc.

Development of underwater welding systems and techniques, preferably for welding in the wet, rather than in the dry. Such systems must eventually be to the standards acceptable for pipelines by the petroleum industry, or by the Registration Societies for Ships and Structures.

Development of underwater cleaning, survey, maintenance and repair systems for ships and structures. Apart from diver operated tools and units, this could include the development of floatable coffer dams or part dry docks, or special chambers in which a dry atmosphere could be provided in which surface workers could carry out the necessary repairs or other work.

Development of underwater 'cranes' using lifting bag or equivalent techniques to exploit buoyancy.

The further development of practical underwater hand tools to suit the many tasks of divers.

The further development of economical and convenient power tools, reactionless where appropriate, and pneumatic, hydraulic or electric according to the type of tool, the depth at which it has to operate, and the method shown to be the most practical for the conditions involved.

The development of compact, light-weight, safe gas generators for displacing seawater at various depths.

The development of improved designs of multi-core cables, cable handling gear and cable connectors for underwater use. These are particularly vulnerable in most present systems, and there is much room for detailed improvement.

Development of underwater demolition techniques.

Field Reference 14

MARINE ASPECTS OF PORTS PROBLEMS

Recommended Topics

Ship Movements

Speed ranges of ships moving in restricted waterways.

Effect of shallow water on motions of ships.

Motion of ships in confined waterways.

Behaviour of small ships in a seaway.

Development of equipment to determine bottom clearance of ships entering harbours.

***Berthing & Mooring**

The effect of hydrodynamic mass on berthing forces.

Collation of information on berthing forces of large ships.

Improved mooring systems.

Study of mooring and anchoring equipment for large ships – new methods of anchoring required.

Offloading of large tankers either between ships, or at offshore station.

Forces developed by anchoring systems and factors affecting them.

Exploiting currents induced by air bubbles to assist in ship manoeuvring and berthing.

Dredging Siltation

Dredging technology

Control of density – induced siltation.

Separation of river bed silt from water by mechanical processes.

Investigations of materials for hopper barges, door sealing arrangements.

Effect of estuary circulation on sedimentation.

Field Reference 15

HANDLING OF BULK MATERIALS

Recommended Topics

Manoeuvrability of trailing suction dredgers with one or two sidepipes in different fore and aft locations.

(As part of the problem of dredger positioning this is significant mainly in channel clearing (capital and maintenance) dredging rather than in sand and gravel dredging. Believed to be a profitable line to pursue in association with ship control techniques and automation. As a result of studies of dredging economics and the CIRIA survey, but depending on support offered, studies may be launched of ship-positioning systems for this and other applications. A short study (as described by heading) would, however, not be inappropriate).

Heavy lift movements within containerisation. Engineering considerations of equipment and handling methods.

*Settlement of material in hopper-dredgers-configuration of discharge pipes and mechanical settling devices.

(Settlement of dredged material in hoppers (Mechanical/hydrodynamic techniques): DTI information is that this could be significant in increasing productivity, but no study in existence; chemical (flocculant) techniques being considered currently by DTI and NPC, should be able shortly to indicate order of improvement required for a non-chemical technique to be viable).

Field Reference 16

SEA-BED INVESTIGATIONS

Recommended Topics

***Mechanisms** (This is an area in which NERC are also interested).

Investigation of mechanisms leading to ripple/dune formation. Movement of sand/gravel under action of waves and currents. Interaction of sea and sea-bed (ie sand waves, shoals, etc.). Long term research into movement of sea floor sediments. Effect of dredging on sea-bed.

Inspection Techniques

Application of nuclear techniques to sea-bed investigations.

Recorders to provide continuous indication of constitution of upper three feet of the sea-bed.

Improved coring methods for soft ground in the open sea.

Acoustic properties of sea-bed, etc. for sonar applications.

Field Reference 17

FISHING TECHNOLOGY, FISH FARMING ENGINEERING

Recommended Topics

Conventional Fisheries

Development of improved sonar systems for locating and identifying fish shoals, both for catching and for surveying the extent of resources including fish-counting.

Development of economical side-scan sonar systems to follow nets and fish shoals in the horizontal and vertical planes, as opposed to solely in the vertical plane, to improve the effectiveness of fish hunting and capture for both pelagic (free-ranging) and demersal (bottom-living) fish.

The development of improved telemetering systems from nets or gear to the fishing vessel.

On-line applications of computers on board ship.

The development of improved and more economical fish catching methods and fishing gear, together with handling methods on board the fishing vessels. This work would require an analysis of the characteristics of towed bodies and the various parts of the gear, to elucidate design parameters, with a view to seeking means of improvement in design and effectiveness.

Studies of propulsion systems and towing winches and other equipment on deck, in relation to their effects on fishing gear and catching efficiency.

Machine tools for automatic gutting, filleting, etc, and associated systems for sorting, size grading, conveying, washing, temperature conditioning etc.

Thermal insulation (freezer trawlers and cold stores).

A study of existing freezing and refrigeration systems in relation to the fish products themselves and to conditions on board ship, with a view to making improvements in operation, safety and economy.

Secondary refrigerants (a non-toxic, non-inflammable, non-corrosive liquid, mobile at minus 55°C).

Shipborne navigation systems.

A study of ship control and navigation problems, with a view to the judicious and economical application of automation to machinery surveillance and ship navigation on passage and while fishing; the object is always to reduce labour and watchkeeping.

Operations research and systems analysis.

A study of the optimum requirements for a fishing port/terminal, including its location, together with the facilities required for dealing with the catch and for servicing and maintaining the fleet in the most economical manner, and taking into account commercial, hygiene, fish quality and other related considerations. The relative merits of independent fish terminals and those closely related to commercial ports should also be studied.

A study should be made of the minimum requirements of a fish terminal to improve the handling of catch and vessels at a typical fishing village in a developing country. This should take into account the need for minimum expenditure and maximum effectiveness, in terms of improving the demand for fish and/or the price paid for it by buyers from inland or other communities.

Active training simulators for fishing skippers.

Aquaculture

A study of the water, wave and other forces on the different types of structure employed in fish farming, with a view to identifying gaps in existing information and to developing improved designs and methods.

A study of the problems involved in establishing fish farming in open water, and the gaps in existing knowledge which need to be filled before such an installation could be attempted.

A study of the engineering problems involved in maintaining the required conditions in different types of enclosures, and the identification of the instrumentation required to permit correct monitoring of the various characteristics; the development of the necessary instrumentation and equipment.

Dynamics of exploited fish populations.

Field Reference 18

INSTRUMENTATION APPLIED TO MARINE ENGINEERING

Recommended Topics

Cheap, reliable wave recorders indicating directions as well as other wave characteristics.

(This requirement has not been highlighted earlier as of great significance, but a number of offshore engineering problems and activities could be dealt with more effectively if meaningful wave data were available. The first problem is to establish what is meaningful, which may differ according to the application; we doubt whether it can be simplified as far as is suggested. NIO and other places have wave-measuring equipment and MATSU is looking into the possibility of rationalising some of the requirements. A study of the significant factors in relation to various offshore operations would be worthwhile; a number of bodies would be interested. The suggested instrumentation can, however, probably be developed from existing technology, and is perhaps not a suitable task for a University).

Data recording and transmission buoys to monitor wind/wave velocities and amplitudes, temperatures and direction.

Information on physical conditions in or surrounding a ship and its equipment.

(The new techniques likely to be needed would be mainly those involved in adapting to the marine environment. DTI are not investigating this aspect of instrumentation).

Survey of design recommendations for shipborne instruments (propulsion, navigation, cargo handling, fire protection, computers etc.) and comparison of effectiveness of equivalent land instruments, marinized-land instruments, and the need for special development.

*The development of a technique for the accurate measurement of large mass flows of cryogenic liquids and vapours. Similar measurement is also required on board ship for other fluids. The primary objective would be for use with custody transfer.

(Many methods of flow measurement exist, including recent ones using sound or light traversing the pipe at an angle; for gases or, especially, for mixed liquid/gas flows these are unlikely to give sufficiently accurate results. The problem, though not exclusively a marine one, appears difficult, interesting and well matched to university investigation).

Shipborne information systems. Study of the total information processing problem in large merchant ships with a view to incorporation of a hierarchy of computer-processors.

Field Reference 19 (See also field reference 06)

SHIP CONTROL SIMULATION

Recommended Topics

*Adaptive and optimal control of marine gas-turbine installations with and without variable-pitch propellers.

An integrated study of yaw stability, steerability, manoeuvrability and automatic steering and engine control systems for large ships.

A study of optimum man-machine systems for the navigation, control and manoeuvring of merchant ships and submersibles.

(The topics proposed above will be included in the DTI systems and automation studies, out of which separable longer-term studies may well emerge).

Use of hybrid computers for simulating non-linear ship manoeuvres.

Investigation of ship response to hydrofoil control systems.

(To DTI knowledge, there is no great emphasis on the use of hydrofoils at present, but the proposal need not be rejected on that account).

Study of human error in Radar using simulation and ergonomic equipment.

Field Reference 20

NAVIGATION (INCLUDING SURVEYING)

Recommended Topics

Navigation

*Study of the techno-economic factors involved in optimum ship routing and weather routing.

*Systems study of a fleet activity in relation to particular cargo-carrying or other activities, bringing in the economic and other factors involved, and isolating where possible the obstacles in present systems, both technical and commercial, to the attainment of optimum efficiency. Simulation computer programmes covering such activities would be of value.

The development of automatic and centralised control of ships from the bridge, but taking into account the paramount requirements concerning safety at sea and the observance of the Rule of the Road.

*Development of means for decelerating very large under-powered vessels such as tankers.

A study of the problems in manoeuvring large vessels in confined and shallow waters, both to negotiate channels and during berthing.

A study of existing methods of transferring at sea, and the development of improved methods, both between ships (stationary or under way) and between small supply vessels and structures such as oil rigs, lighthouses, etc.

A study of existing dynamic positioning systems, and the development of a new optimum and cheap system.

A study of the problems involved in underwater navigation and position-fixing, and the development of improved and more reliable methods, taking into account various possibilities including inertial, acoustic and other systems.

The development of automatic track-keeping systems, with special reference to the avoidance of collisions at sea.

The development of low-cost materials for Satnav to permit the facility for continuous fixing.

A study of bridge layout and the arrangement of navigational equipment and displays on ergonomic lines, to improve ship control and safety.

A study of the propagation characteristics of subsonic radiation in clear weather and in fog leading to the development of efficient equipment for generating subsonic sound, and also for its detection and sensing by direction and, if possible, distance.

The development of an under-way draught gauge for large vessels.

Surveying

Development of a wide-band true-to-scale double-side sector-scan acoustic system for bottom surveying.

Development of a surveying system incorporating automatic chart reduction.

*Development of a reliable deep water tide gauge and recording/telemetering system with the possibilities of developing an advance information system to advise approaching vessels of the tidal height.

Field Reference 21

UNDERWATER VIEWING, PHOTOGRAPHY AND OBJECT LOCATION

See Field Reference 11 et seq.

Field Reference 22

UNDERWATER COMMUNICATION

See Field Reference 11 et seq.

Field Reference 23

POLLUTION

Recommended Topics

*Handling bulk materials and pollution.

*Pollution near undersea structures.

*Effect of harbour construction on pollution.

Turbulent diffusion and marine effluent dispersal.

*Design of outfall pipes for sewage and heavy liquids, and their pollution pattern.

Marine surface diffusion as a function of wind speed.

Activation analysis techniques for estimating:

i radioactive waste

ii sea water pollutants

iii dangerous trace elements in fish

Two-dimensional numerical model studies of marine pollution problems.

Design of pollution indication device for use in rivers and coastal waters.

Field Reference 24

SAFETY AT SEA

Recommended Topics

Control problems involved in compensating for ship's heave, roll, pitch and yaw when handling objects inboard and outboard, in order to reduce vertical and pendulum motions of the load.

*Systems of centralised ship-position monitoring in confined waters.

*Submerged tide recorder with telemetering to land.

*The effect of a seaway on the stability of a ship.

*The behaviour of slurries within a ship under the effects of hull vibration and/or ship movements and its effect on the stability of a ship.

Fundamental research into the basic physics and chemistry of the initiation of ignition of hydrocarbon/air mixture.

Development of a technique for the safe disposal of 100% light hydrocarbon vapours from liquefied natural gas tanker.

*Examination of marine accident statistics and their analysis according to types of accident, causative factors etc. Correlation of this information with ship type, crew training and qualifications etc.

*Ergonomic study of commonly used ships instruments and equipment such as compass, engine room telegraph, helm angle indicators etc., with the object of unifying and improving designs so as to improve accuracy in use and to reduce incidence of error at the instrument/human interface.

*Ergonomic study of ships structural features such as ladders, doors, hatches, bunks etc. with the aim of improving designs so as to reduce the risk of injury due to slipping and falling when the ship rolls and general improvement of comfort levels.

Field Reference 25

SHIP PRODUCTION AND MANUFACTURING SYSTEMS

The table below summarises the specific suggestions for research under five sub-headings.

The largest group of suggestions for further work concerns methods of improving some basic shipbuilding processes. Most of these are essentially problems in applied

mechanics and production engineering; in some of them the scale of the practical problem may present difficulties for University research.

The next largest group concerns proposals for work in applications of the computer to ship production, and in ways of reducing production costs. Both of these are receiving attention at Strathclyde and Newcastle, and at BSRA; but more needs to be done. In both areas, the practical implementation of improved methods by the shipbuilding industry remains a source of difficulty. A similar comment applies to the two studies proposed on the larger problems of shipbuilding strategy and corporate planning.

The final small group is of the kind which could well expand rapidly if non-ferrous materials come to be widely adopted for marine use. In the context of ocean engineering, these seem well worthy of further study.

Recommended Topics

Organisation and Planning

Application of group technology techniques to shipbuilding

Mathematical model for corporate planning in shipyards

Cost Studies

Design for economic manufacture and costing

Value analysis in shipbuilding

Study of shipbuilding costs

Design-production studies for minimum cost

Computer-Aided Production

Automation of shipbuilding processes

Use of graphic terminals in ship production

Steel flow studies for N/C applications

Dynamic modelling of assembly processes

Plant and Processes

Methods of bending thick plates

Techniques for defining non-developable surfaces

Fundamentals of welding and cutting

Devices for positioning large, heavy units

Methods of reducing weld distortion

Development of steelwork jigging system

Construction Problems in New Materials

Concrete construction for marine uses

Concrete and GRP production problems

Example IV
1974

Excerpted from

"British National Committee on Ocean Engineering: National Policy on Seabed Engineering," Council of Engineering Institutions, London, May 1974.

This report is a broad policy report similar in tone and sweep to the Stratton Commission Report on which one feels it depended to some extent. The major intent of the report is to discuss management of an ocean engineering effort having established broad policy recommendations. Of particular interest to the ocean engineering panel was enclosure 17 which indicated the fields in which Navy activities could assist in other marine activities and simply indicated how broad and how deep the question of technical transfer from naval to the civilian areas might run.

Table I

Some Fields in Which Defense Experience Can Assist Other Marine Activities

N.B. Not all the items listed below presently exist at least in the form described.

I. Vessels and Craft

a. Warships, submarines, Royal Fleet Auxiliaries, auxiliary and harbour craft
b. Salvage and rescue craft—tugs (ocean and harbour), lifting craft, heavy lift cranes, diving vessels, helicopters
c. Submersibles, telechirics, habitats
d. Hydrographic and research craft and vessels
e. Mooring, buoy and boom defense vessels and systems

II. Engineering

a. Propulsion systems
b. Auxiliaries and systems, including automation
c. Desalination
d. Ship construction
e. Materials, corrosion, protection

III. Electronics

a. Communications, radio and visual
b. Position-fixing systems for navigation and hydrography
c. Radar
d. Underwater acoustics—echo sounders, sonar (side-scan, doppler, etc.)
e. Underwater communications, navigation, search and location
f. Ship control and collision avoidance systems. Training simulator system
g. Instrumentation
h. Data acquisition, processing, storage, dissemination. Buoy systems
i. Meteorological systems—weather, storm, tide prediction

IV. Other Facilities

a. Diving and underwater work systems and techniques. HMS "Reclaim" replacement
d. Environmental testing centres, and sea-borne "test beds"
c. Structural, shock and vibration testing facilities
d. Structural testing at full scale
e. Desalination experimental station

f. In-water survey, maintenance and repair techniques

g. Hydrographic and oceanographic survey and chart-making systems

h. Meteorological forecasting systems

i. Pollution monitoring and counter-measures

V. Research and Development

a. Procurement Executive

1. Research and development establishments
2. Outside contracts with industry, universities, etc.

VI. Miscellaneous

a. Procurement of ships, equipment, services, stores

b. Defense sales (exports)

VII. Education and Training

How odd that the academic ~~man~~ Engineering community is much larger than the academic scientific community yet the engineers have no ships but come to the scientists for them.

This is perhaps the most conspicuous symptom of lack of maritime gumption amongst the engineering educational fraternity.